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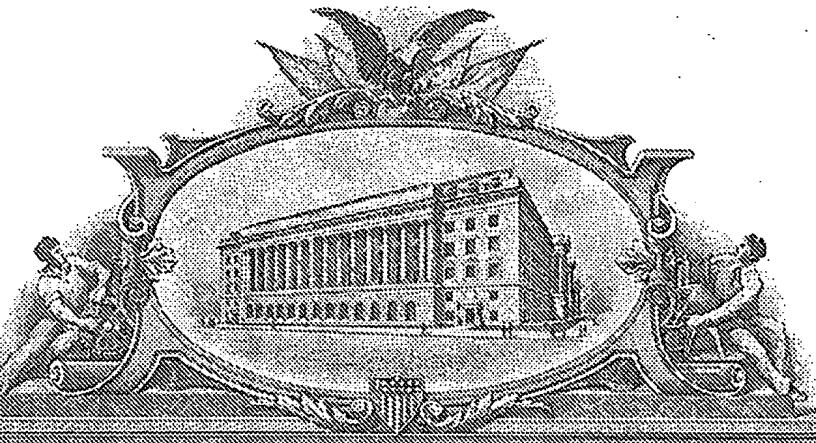
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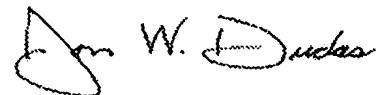
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.**PROVISIONAL APPLICATION FOR PATENT COVER SHEET**

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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<input checked="" type="checkbox"/> Additional inventors are being named on the <input checked="" type="checkbox"/> separately numbered sheets attached hereto		
TITLE OF THE INVENTION (280 characters max)		
TITLE		
DEVICE AND METHODS OF MEASURING PRESSURE		
Direct all correspondence to: CORRESPONDENCE ADDRESS		
<input type="checkbox"/> Customer Number <input type="text"/> Customer Number <input type="text"/> Customer Number Bar Code		
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ENCLOSED APPLICATION PARTS (check all that apply)		
<input checked="" type="checkbox"/> Description of Patent Disclosure Number of Pages 9 <input type="checkbox"/> CD(s), Number <input type="text"/> <input checked="" type="checkbox"/> Drawings 3 <input type="checkbox"/> Other: Prepaid Return Postcard <input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76		

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.	FILING FEE AMOUNT (\$)
<input type="checkbox"/> A check or money order is enclosed to cover the filing fees	
<input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 23-0503	

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

No Yes, the name of the U.S. Government agency and the Government contract number are:

Respectfully submitted,

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Date **March 5, 2004**REGISTRATION NO.
(if appropriate)**29,809**

Docket Number:

04-392**USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT**

Docket No. 04-392

PROVISIONAL APPLICATION PATENT COVER SHEET

SECOND PAGE

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Docket No. 04-392

**CERTIFICATE OF MAILING BY "EXPRESS MAIL"
(37 CFR § 1.10) No. EL 908622938 US**

APPLICANT(S): **WATERS INVESTMENTS LIMITED**
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TITLE OF INVENTION:

DEVICE AND METHODS OF MEASURING PRESSURE

FILING DATE: HEREWITH

ASSIGNEE: **WATERS INVESTMENTS LIMITED**

APPLICATION NUMBER (if known): **UNKNOWN**

MAIL STOP- PROVISIONAL APPLICATION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I hereby certify that the correspondence identified in the transmittal below is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 in an envelope addressed to: Mail Stop Provisional Applications, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on March 5, 2004.

Susan M. Farja
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TRANSMITTAL LETTER

Enclosed for filing in the above identified provisional patent application are the following documents:

Provisional patent application transmittal letter (2 pgs); specifications including claims and abstract (9 pgs), formal drawings (3 pgs) and prepaid return postcard.

March 5, 2004
Reg. No. 29,809

Anthony J. Januk
Anthony J. Januk

DEVICE AND METHODS OF MEASURING PRESSURE

5 FIELD OF THE INVENTION

This invention relates to pumps and methods of measuring pressure within a pump chamber.

10 BACKGROUND OF THE INVENTION

It is desirable to measure the pressure inside a pump chamber. In some fields, pumps have decreased in size such that the placement of stress gauges on the housing of the pump has become difficult. For example, for pumps used in liquid chromatography it is 15 desirable to operate at pressures greater than 3,000 pounds per square inch (psi). This pressure represents the normal upper limit of conventional chromatographic apparatus. Pressures in the ultra pressure region of greater than 4,000 up to 12,000 psi are desired. To attain these high pressures pump chambers are machined with greater precision. There is less area in the pump chamber to receive connections to pressure sensors.

20 SUMMARY OF THE INVENTION

Embodiments of the present invention are directed to method and devices for measuring the pressure of a pump chamber in which no internal opening or connections are needed. 25 One embodiment of the present invention is directed to an apparatus for pumping fluid. The apparatus comprises at least one housing. The housing has an exterior surface and an interior surface. The interior surface defines a chamber for receiving a plunger and having a fluid input opening and a fluid discharge opening extending between said interior and exterior surfaces. The chamber has a cylindrical shape with a first end wall 30 and a plunger opening for receiving a plunger. The exterior surface of the housing has a transducer surface between the first end wall and the plunger opening. The interior surface and exterior surface define a first thickness and a second thickness. The transducer surface has the second thickness exhibiting measurable deformation upon the chamber holding a fluid under pressure such that the transducer surface having a first 35 position at which the chamber is at one pressure and a second position at which the chamber is at a second pressure. A plunger is received in the plunger opening for reciprocating movement in the chamber. The reciprocating movement causing fluid movement, to enter the chamber through the fluid input opening and out through the fluid discharge opening. At least one strain sensor is affixed to the transducer surface. The 40 strain sensor producing at least one signal upon the transducer surface assuming the first position and at least one signal upon the transducer surface assuming the second position to function as an integrated pressure transducer.

45 Preferably, the transducer surface is a flat surface capable of deformation upon pressurization of said chamber.

Preferably, the housing has a composition selected from the metals and metal alloys consisting of titanium, aluminum, and vanadium. A most preferred metal and metal alloy is titanium, aluminum and vanadium alloy, 6Al4V.

5

Preferably, the exterior surface of the housing has a cylindrical portion and a half cylindrical portion. The cylindrical portion forms a base for attachment to other apparatus. Such other apparatus normally would consist of pump motors and supporting structure for holding the pump within a frame or further housing. The half cylindrical portion has a flat planar surface and a half cylindrical surface. The half cylindrical portion and the cylindrical portion can also be made as separate units and joined into a unitary structure. The two separate pieces can be made of different materials. It is useful to make the unit or portion having the transducer surface of the titanium alloy. For cost considerations, it may be useful to make the base unit of stainless steel.

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portion has a flat planar surface and a half cylindrical surface. The half cylindrical portion and the cylindrical portion can also be made as separate units and joined into a unitary structure. The two separate pieces can be made of different materials. It is useful to make the unit or portion having the transducer surface of the titanium alloy. For cost considerations, it may be useful to make the base unit of stainless steel.

15

Preferably, the transducer surface is a bottom surface of a cavity in said flat planar surface. That is a, a cavity is machined into the flat surface to provide a transducer surface. The cavity provides a second thickness, the thickness subject to deformation, of approximately 0.10 to 0.001 inches, more preferred, approximately 0.05 to 0.005 inches, and, more preferred, 0.040 to 0.01 inches. In one preferred embodiment, the cavity provides a second thickness of .029 plus or minus .001 inches.

20

Circuits and the like which amplify the signal of the strain sensor are preferably mounted on the flat planar surface. The circuits and strain sensor are preferably covered by a cover for protection.

25

A further embodiment of the present invention is directed to a method of measuring pressure in a pump chamber. The method comprises the steps of providing at least one housing having an exterior surface and an interior surface. The interior surface defines a chamber for receiving a plunger. The housing further has a fluid input opening and a fluid discharge opening extending between said interior and exterior surfaces. The chamber having a cylindrical shape with a first end wall and a second end wall. At least one end wall has a plunger opening for receiving a plunger. The exterior surface of the housing has a transducer surface between the first end wall and the second end wall. The interior surface and exterior surface define a first thickness and a second thickness. The transducer surface having the second thickness and exhibiting measurable deformation upon the chamber holding a fluid under pressure such that the transducer surface has a first position at which the chamber is at one pressure and a second position at which said chamber is a second pressure. A plunger is received in the plunger opening for reciprocating movement in the chamber. The reciprocating movement causing fluid movement to enter the chamber through the fluid input opening and out through the fluid discharge opening. At least one strain sensor is affixed to the transducer surface, The strain sensor produces at least one signal upon said transducer surface assuming the first position and at least one signal upon the transducer surface assuming the second position to function as a integrated pressure transducer. The method further comprising the step of taking readings of the strain sensor as an indication of pressure in the chamber.

These and other features and advantages will be apparent upon reading the following detailed description of the invention and viewing the drawing.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts in cross section a side view of an apparatus embodying features of the present invention;

10 Figure 2 depicts in cross section, an end view of an apparatus embodying features of the present invention;

Figure 3 depicts in top view, an apparatus embodying feature of the present invention.

15 Detailed Description of the Invention

The present invention will be described as a method and device for measuring the pressure of a pump chamber in which no internal opening or connections are needed.

The invention has special application to pumps used in chromatography and chemical

20 analysis. However, individuals skilled in the art will recognize that the present invention has applications in other fields as well. Individuals skilled in the art will further recognize that the present invention is subject modifications and alterations without deviating from the overall teaching of the present discussion which by way of example, without limitation discloses one or more preferred embodiments.

25 Turning now to Figure 1, an apparatus, generally designated by the numeral 11, is depicted. Apparatus 11 is for pumping fluid. Apparatus 11 comprises at least one housing 13, a plunger 15 and a strain sensor 17.

30 Housing 13 has an exterior surface 21 and an interior surface 23. The interior surface defines a chamber 25 for receiving the plunger 15. A fluid input opening 29 and a fluid discharge opening (not shown) extends between said interior surface 23 and exterior surfaces 21. A check valve 33 is depicted in communication with the fluid input opening 29. The fluid outlet opening would normally have fittings for communication with other assemblies and conduits in a manner well known in the art.

35 The chamber 25 has a cylindrical shape with a first end wall 31 and a plunger opening 35 for receiving plunger 15. Individuals skilled in the art will recognize that the chamber may deviate from a perfect cylinder and encompass forms with one or more sides while 40 retaining the function of cooperation with the plunger 15. Plunger 15 is received in the plunger opening 35 for reciprocating movement in the chamber 25. The reciprocating movement causes fluid movement. Fluid enters the chamber through the fluid input opening 29 and out through the fluid discharge opening (not shown).

45 The exterior surface 21 of housing 13 has a transducer surface 41 between the first end wall 31 and plunger opening 35. The interior surface 23 and exterior surface 21 define a

first thickness and a second thickness. The first thickness is for structural integrity and minimal elasticity. The second thickness exhibits deformation upon pressure induced stress. The transducer surface 41 has a second thickness exhibiting measurable
5 deformation upon the chamber 25 holding a fluid under pressure. That is, the transducer surface 41 has a first position at which the chamber is at one pressure and a second position at which the chamber is at a second pressure. Strain sensor 17 is affixed to the transducer surface 41. Strain sensor 17 produces at least one signal upon the transducer surface assuming the first position and at least one signal upon the transducer surface
10 assuming the second position to function as an integrated pressure transducer.

As depicted in Figure 2, the transducer surface is a flat surface capable of deformation upon pressurization of said chamber. However, curved or irregular surfaces can be used with appropriate strain sensors 17.

15 Housing 13 has a composition selected from the metals and metal alloys consisting of titanium, aluminum, and vanadium. A most preferred metal and metal alloy is titanium, aluminum and vanadium alloy, 6Al4V.

20 Preferably, the exterior surface 21 of housing 11 has a cylindrical portion 45 and a half cylindrical portion 47. The cylindrical portion 45 forms a base for attachment to other apparatus (not shown). Such other apparatus normally would consist of pump motors and supporting structure for holding the pump within a frame or further housing.

25 As best seen in Figures 2 and 3, the half cylindrical portion 47 has a flat planar surface 51 and a half cylindrical surface 53. As used herein, the term "half" is used to mean part cylindrical and not a precise division. Turning now to Figures 1 and 2, the half cylindrical portion 47 and the cylindrical portion 45 can also be made as separate units and joined into a unitary structure. The two separate pieces can be made of different
30 materials. It is useful to make the unit or portion having the transducer surface of the titanium alloy. For cost considerations, it may be useful to make the base unit, that is the cylindrical portion 45 of stainless steel.

35 Preferably, the transducer surface 41 is a bottom surface of a cavity 55 in the flat planar surface 51. That is, a cavity 55 is machined into the flat surface to provide a transducer surface 41. The cavity 55 provides a second thickness, the thickness subject to deformation, of approximately 0.10 to 0.001 inches, more preferred, approximately 0.05 to 0.005 inches, and, more preferred, 0.040 to 0.01 inches. In one preferred embodiment, the cavity 55 provides a second thickness of .029 plus or minus .001 inches.

40 Circuits and the like which amplify the signal of the strain sensor 17 are incorporated on a circuit board 61 and mounted on the flat planar surface. The circuit board 61 and strain sensor 17 are preferably covered by a cover 63 for protection.

45 A further embodiment of the present invention is directed to a method of measuring pressure in a pump chamber 25. The method comprises the steps of providing

a housing 13 having an exterior surface 21 and an interior surface 23. The interior surface 23 defines a chamber 25 for receiving a plunger 15. The housing 13 further has a fluid input opening 29 and a fluid discharge opening (not shown) extending between said interior surface 23 and exterior surface 21. The chamber 25 has a cylindrical shape with
5 a first end wall 31 and a plunger opening 35 for receiving plunger 15. The exterior surface 21 of the housing 13 has a transducer surface 41 between the first end wall 31 and the plunger opening 35. The interior surface 21 and exterior surface 23 define a first thickness and a second thickness. The transducer surface 41 having the second thickness and exhibiting measurable deformation upon the chamber 25 holding a fluid under
10 pressure such that the transducer surface 41 has a first position at which the chamber is at one pressure and a second position at which said chamber 25 is a second pressure. A plunger 15 is received in the plunger opening 35 for reciprocating movement in the chamber 25. The reciprocating movement causes fluid movement. Fluid enters the chamber 25 through the fluid input opening 29 and out through the fluid discharge
15 opening (not shown). At least one strain sensor 17 is affixed to the transducer surface 41. The strain sensor 17 produces at least one signal upon said transducer surface 41 assuming the first position and at least one signal upon the transducer surface 41 assuming the second position to function as a integrated pressure transducer. The method further comprising the step of taking readings of the strain sensor 17 as an indication of
20 pressure in said chamber.

Thus, embodiments of the present invention and how to make and use the invention have been described with the understanding that the description is that of preferred embodiments subject to change and variation. And, the invention should not be so limited to such description but should encompass the subject matter of the following claims.
25

CLAIM

5 1. An apparatus for pumping fluid comprising:

at least one housing, said at least one housing having an exterior surface and an interior surface, said interior surface defining a chamber for receiving a plunger and having a fluid input opening and a fluid discharge opening extending between said interior and 10 exterior surfaces, said chamber having a cylindrical shape with a first end wall and a plunger opening for receiving a plunger; wherein said exterior surface of said at least one housing has a transducer surface between said first end wall and said second end wall, said interior surface and exterior surface define a first thickness and a second thickness, said transducer surface having said second thickness exhibiting measurable deformation 15 upon said chamber holding a fluid under pressure such that said transducer surface having a first position at which the chamber is at low pressure and a second position at which said chamber is at high pressure;

20 a plunger received in said plunger opening for reciprocating movement in said chamber said reciprocating movement causing fluid movement to enter said chamber through said fluid input opening and out through said fluid discharge opening; and,

25 at least one strain sensor affixed to said transducer surface, said strain sensor producing at least one signal upon said transducer surface assuming said first position and at least one signal upon said transducer surface assuming said second position to function as a integrated pressure transducer.

30 2. The apparatus of claim 1 wherein said at least one housing transducer surface is a flat surface capable of deformation upon pressurization of said chamber.

3. The apparatus of claim 1 wherein said housing has a composition selected from the metals and metal alloys consisting of titanium, aluminum, and vanadium .

4. The apparatus of claim 1 wherein said metal and metal alloy is titanium, aluminum and vanadium alloy 6Al4V.
5. The apparatus of claim 1 wherein said exterior surface of said housing has a cylindrical portion and a half cylindrical portion, said cylindrical portion forming a base for attachment to other apparatus, said half cylindrical portion having a flat planar surface and a half cylindrical surface.
6. The apparatus of claim 5 wherein said transducer surface is a bottom surface of a cavity in said flat planar surface.
7. The apparatus of claim 6 wherein said second thickness is approximately 0.10 to 0.001 inches.
8. The apparatus of claim 7 wherein said second thickness is approximately 0.05 to 0.005 inches.
9. The apparatus of claim 8 wherein said second thickness is 0.040 to 0.01 inches.
10. A method of measuring pressure in a pump chamber comprising the steps of providing at least one housing, said at least one housing having an exterior surface and an interior surface, said interior surface defining a chamber for receiving a plunger and having a fluid input opening and a fluid discharge opening extending between said interior and exterior surfaces, said chamber having a cylindrical shape with a first end wall and a plunger opening for receiving a plunger; wherein said exterior surface of said at least one housing has a transducer surface between said first end wall and said second end wall, said interior surface and exterior surface define a first thickness and a second thickness, said transducer surface having said second thickness exhibiting measurable deformation upon said chamber holding a fluid under pressure such that said transducer surface having a first position at which the chamber is at low pressure and a second position at which said chamber is at high pressure;

a plunger received in said plunger opening for reciprocating movement in said chamber said reciprocating movement causing fluid movement to enter said chamber through said fluid input opening and out through said fluid discharge opening; and

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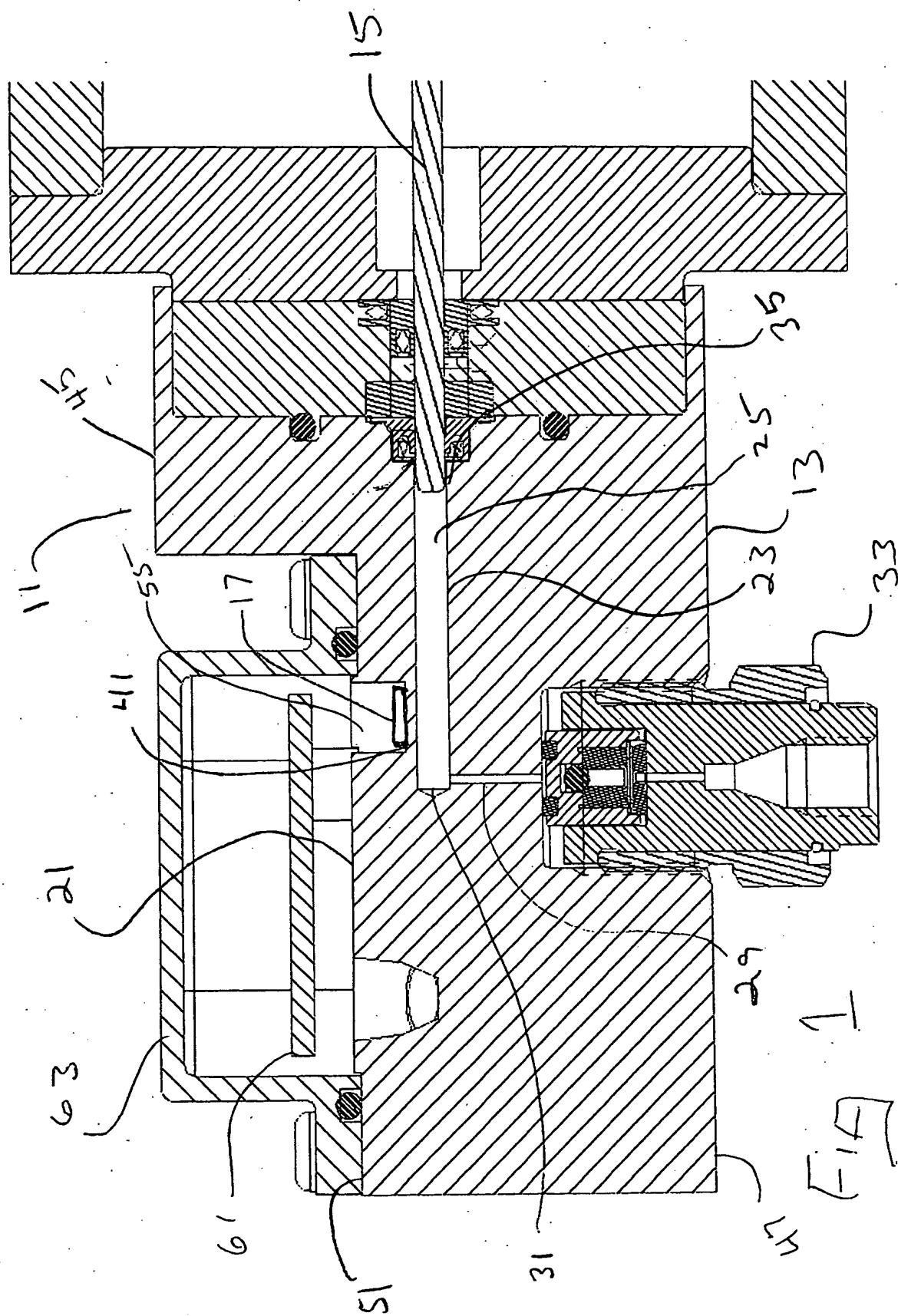
at least one strain sensor affixed to said transducer surface, said strain sensor producing at least one signal upon said transducer surface assuming said first position and at least one signal upon said transducer surface assuming said second position to function as a integrated pressure transducer;

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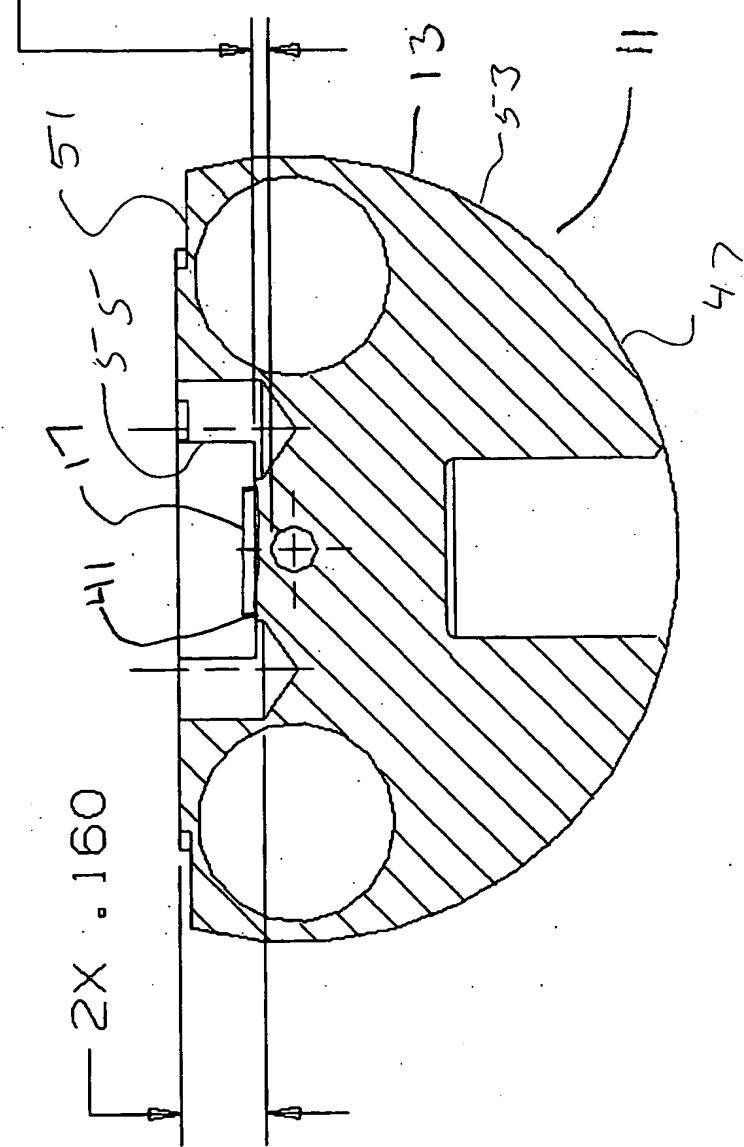
and taking readings of the strain gauge as an indication of pressure in said chamber.

ABSTRACT

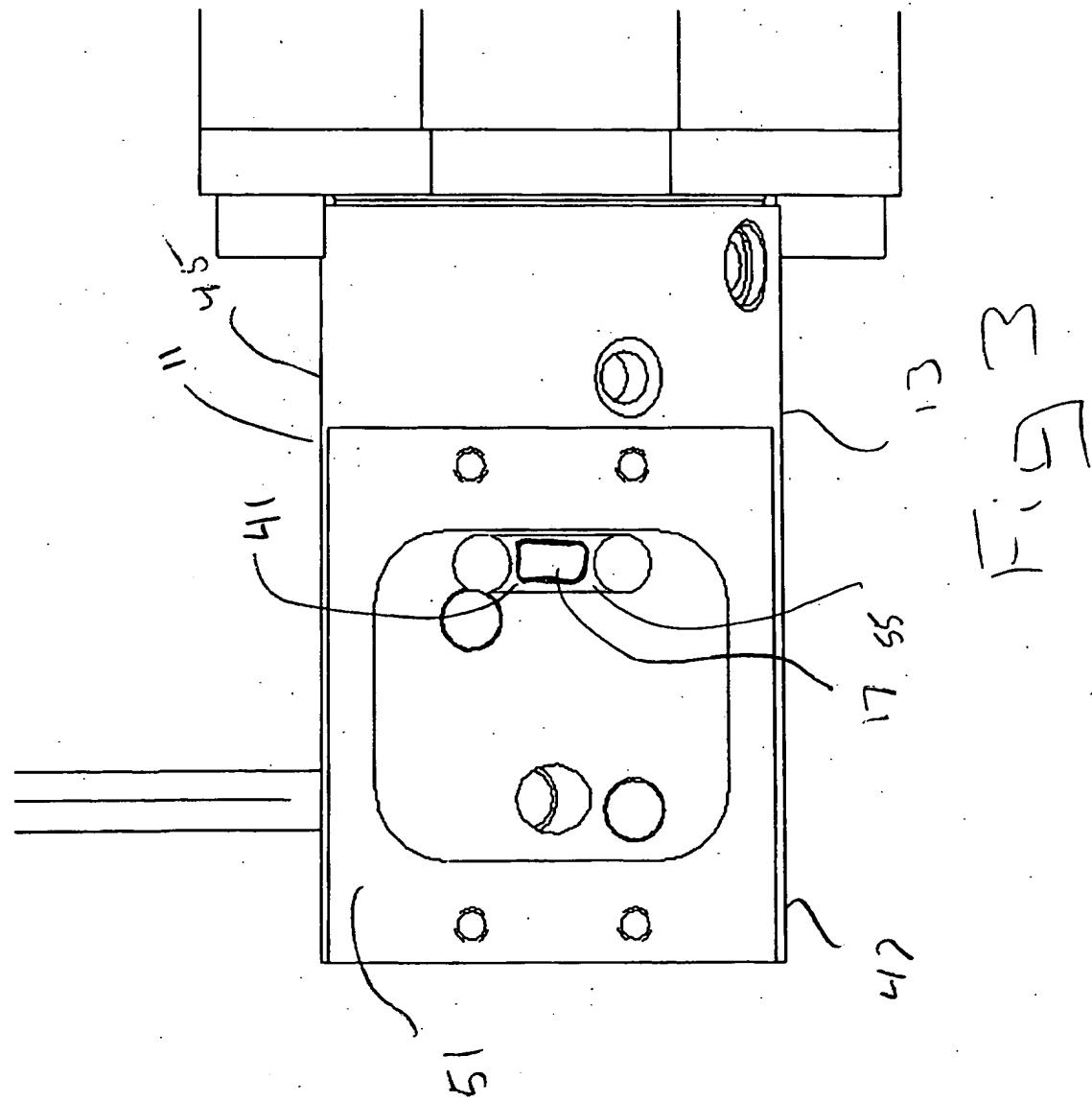
Embodiments of the present invention are directed to method and devices for measuring
5 the pressure of a pump chamber in which no internal opening or connections are needed. One embodiment of the present invention is directed to an apparatus for pumping fluid. The apparatus comprises at least one housing having a transducer surface. The transducer surface has a thickness exhibiting measurable deformation upon the chamber holding a fluid under pressure such that the transducer surface has a first position at
10 which the chamber is at one pressure and a second position at which the chamber is at a second pressure. A strain sensor is affixed to the transducer surface producing at least one signal upon the transducer surface assuming the first position and at least one signal upon the transducer surface assuming the second position to function as an integrated pressure transducer.



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